

A new species of *Sonorella* (Pulmonata: Helminthoglyptidae) from Arizona, with notes on predation and evasive behaviors

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Abstract: A new species of *Sonorella* Pilsbry, 1900, from the Pedregosa Mountains of southeastern Arizona USA, is described. It shows many similarities to *Sonorella binneyi* Pilsbry and Ferriss, 1910. The desert box turtle, *Terrapene ornata luteola* Smith and Ramsey, 1952, is a predator of the snail.

Key words: box turtle, land snail, Pedregosa Mountains

The genus *Sonorella* Pilsbry, 1900, is comprised of numerous species of medium to large (13-30 mm diameter) land snails. They inhabit a five state area of the southwestern U.S. and northern Mexico, reaching their greatest diversity in the mountain ranges of southeastern Arizona, including the massive Chiricahua Mountains. At present, there are seven described species of *Sonorella* from this range and its northern extension, the Dos Cabezas Mountains (Bequaert and Miller 1973).

The new species, described herein, is found in the Leslie Canyon National Wildlife Refuge located in the Pedregosa Mountains, a southwestern extension of the Chiricahuas. It was discovered by WRR on 18 September 2000 following an overnight summer rainstorm when an individual was observed crawling in a funnel trap made of fine wire mesh used to monitor amphibians and reptiles (Manley and Radke 2002).

MATERIALS AND METHODS

Active specimens of the new species were hand-collected in the field by WRR following summer monsoonal rains (primarily 10 August 2002), and by both authors, along with Jacob Malcom, on 24 February 2005, after a series of heavy winter rains. Numerous shells were collected in talus accumulations at various other times when live specimens could not be found (primarily 10 April 2001). In addition, three estivating topotypes of *Sonorella binneyi* Pilsbry and Ferriss, 1910, were collected by LHG and Bobby Ray Holroyd Jr. on 2 April 2003.

For descriptive and comparative studies of the reproductive organs, eleven specimens of the new species and the three specimens of *Sonorella binneyi* were drowned, removed from their shells, and dissected. Their reproductive systems were separated from the other organs, stained with Delafield

Hematoxylin, counterstained with Eosin B, and mounted on slides for microscopic examination (see Gregg 1959, Naranjo-García 1989). It was then determined that seven specimens of the new species and one specimen of *S. binneyi* were sexually mature.

Radulae were prepared for scanning electron microscopy by removal from the buccal mass and subsequent attachment to copper coins using double-sided adhesive tape. The coins were mounted on SEM stubs using carbon-adhesive tabs and sputter-coated with gold-palladium. Shells were cleaned in an ultrasound chamber and mounted directly on SEM stubs with clay and carbon-adhesive tabs prior to sputter-coating. Micrographs were taken with a Hitachi S-3000N scanning electron microscope.

The taxonomy used herein follows Turgeon *et al.* (1998). For the genus *Sonorella*, Turgeon *et al.* (1998) rely heavily on Bequaert and Miller (1973), which, in turn, modifies and elaborates on Pilsbry (1939). Supraspecific phylogeny-based taxa are from Roth's (1996) cladistic analysis of the family Helminthoglyptidae.

Abbreviations of institutions referred to in this article are as follows: ANSP, Academy of Natural Sciences of Philadelphia; CNMO, Colección Nacional de Moluscos (Mexico); LACM, Natural History Museum of Los Angeles County; SBMNH, Santa Barbara Museum of Natural History; USNM, National Museum of Natural History - Smithsonian Institution.

PREDATION AND EVASIVE BEHAVIORS

Predation. The desert box turtle (*Terrapene ornata luteola* Smith and Ramsey, 1952) is a significant predator of the new species of *Sonorella*, described herein. On the morning of 12 August 2002, after an overnight monsoonal rain-

storm measuring 12.5 mm, one was observed in the process of eating an active snail by WRR. The turtle was collected and its feces were found to be full of shell fragments of the new species. It is believed that this is the first account of a *Sonorella* being eaten by a box turtle.

Evasive behaviors: Captive snails were occasionally observed to exhibit evasive behaviors when disturbed (prodded), especially upon emerging from estivation (LHG). On certain occasions, when prodded, a snail would initially crawl two to three times faster than normal and then rotate its shell rather rapidly (for a snail), giving the visual effect of swinging it back and forth. One snail was observed to exude orange-colored mucus during its initial flight reaction. This snail then arched its body upward, crawled with a lurching motion, and began rotating (swinging) its shell. These behaviors lasted for about 20-30 seconds.

Subsequently, on the morning of 29 July 2004, following overnight rains of 9.5 mm at the type locality, several active, adult snails were located, and similarly prodded by WRR. About one in three specimens exhibited evasive behaviors like those described above, especially with regard to the discharge of orange mucus and the rapid shell rotation (the snails appeared to wiggle).

SYSTEMATICS

Superfamily HELICOIDEA

Family HELMINTHOGLYPTIDAE Pilsbry, 1939

Clade Sonorellomorpha Roth, 1996

Clade Sonorellales Roth, 1996

Genus *Sonorella* Pilsbry, 1900

Sonorella pedregosensis sp. nov.

(Figs. 1-5A; Tables 1, 2)

Diagnosis: A relatively small *Sonorella* with a depressed-

globose, umbilicate shell. Male genitalia exhibit a long, coiled epiphallus, and a smooth, moderately thick verge with an apical, heart-shaped, glandiform structure.

Body coloration: Tentacles black; body integument gray-brown (occasionally black) with narrow, tan, mid-dorsal stripe. Mantle collar slightly off-white, sometimes with yellowish tinge; pallial membrane unpigmented. Foot tan.

Description of shell of holotype (Fig. 1; Table 1): Shell comparatively small in size (diameter 17.8 mm, height 11.0 mm), with 4.5 whorls, depressed globose, umbilicate (umbilicus 2.2 mm diameter, contained about 10 times in the major diameter of the shell), rather thin/translucent, medium tan in color with a silky-lustrous periostracum. Embryonic whorls 1.7 in number; first half-turn with ripples followed by two-thirds turn with spirally descending and ascending threads, some with cross-threads between them. Neanic whorls exhibit numerous collabral growth striae and a wide (1.4 mm), reddish-brown shoulder band on last 2.4 whorls (narrowly visible above suture on last 0.4 of antepenultimate and first 0.7 of penultimate whorls). Aperture large, oblique, rounded, slightly wider than high, margins converging. Parietal callus rather thin. Peristome slightly expanded; columellar lip elongated forward and reflected, partially covering umbilicus (approximately 10%).

Paratypes (Fig. 2, Table 1): Ten representative paratypes range from 16.5×10.2 to 18.1×11.8 with a mean of 17.5×11.0 (diameter \times height in mm). There is some variation with regard to the strength and number of the apical threads. Some shells have a simple peristome while a few others have a more thickened one than holotype.

Description of jaw and radula (Fig. 3): Jaw with 6-7 moderate-sized ribs (based on observations of 3 jaws).

Radulae somewhat variable; one specimen with 83 teeth per row (41-1-41), another with 77 (38-1-38). Central and



Figure 1. *Sonorella pedregosensis* Gilbertson and Radke, sp. nov., holotype: apical view (left), apertural view (middle), umbilical view (right). LACM 3046. Shell 17.8×11.0 mm.

Table 1. Measurements (mm) of holotype (LACM 3046) and representative paratypes of *Sonorella pedregosensis* Gilbertson and Radke, sp. nov. Mean values are for paratypes only.

Specimen	# of whorls	Shell diameter	Shell height	Aperture	
				Width	Height
Holotype	4.5	17.8	11.0	10.0	8.7
Paratypes	4.4	18.0	11.9	9.6	8.2
	4.2	17.8	10.8	9.9	8.2
	4.2	16.5	10.2	9.0	8.1
	4.5	18.0	10.8	10.2	8.6
	4.7	16.8	10.9	9.1	8.1
	4.5	17.6	11.3	9.8	8.2
	4.4	18.1	11.8	10.5	9.0
	4.6	17.1	11.0	9.1	8.5
	4.5	17.7	11.4	9.6	8.6
	4.5	17.4	10.2	9.8	8.5
	\bar{x}	4.5	17.5	11.0	9.7

lateral teeth with bluntly pointed cusps; central tooth slightly smaller than laterals. Ectocone formation gradual, beginning on approximately the 12th tooth; mesocones of above the 17th tooth becoming bifid. Marginal teeth have blunt, bifid mesocone; occasional teeth show bifid ectocones. Outer 3-4 marginals have shorter cusps than previous teeth, most with bifid ectocones.

Description of reproductive anatomy of holotype (Fig. 4; Table 2): Description based on stained, slide-mounted, illustrated preparation of holotype. Hermaphroditic duct, albumen gland, and uterus typical in appearance; vagina slightly more than half the length (0.6) of penis. Spermathecal duct moderately long, unbranched; spermatheca rather large, round. Penis fairly large in size with numerous, finely corrugated, internal rings of tissue (presumably glandular) in proximal half. Verge slightly more than half the length of penis, moderately thick (1.0 mm in diameter), relatively smooth, exhibiting a rounded, heart-shaped, glandiform structure at apex. Cleavage of "heart" leading to a short, central, bluntly rounded protrusion (shown as a short line on figure). Opening of seminal duct on dorsal surface of central protrusion with slit continuing proximally along left edge of cleavage; shorter secondary or vestigial slit along right edge. Penial lumen surrounds verge, clearly separating it from inner wall of penis. Penial sheath envelops lower half of penis. Epiphallus coiled and elongate, approximately twice length of penis; proximal region slightly enlarged and connected to penial sheath by broad band of connective tissue; short distal section embedded in penial retractor muscle. Epiphallic cecum comparatively long (about 1.5 mm), detached. Penial retractor muscle short (contracted), inserting on epiphallus noticeably above (1.6 mm) apex of penis and continuing to apex.

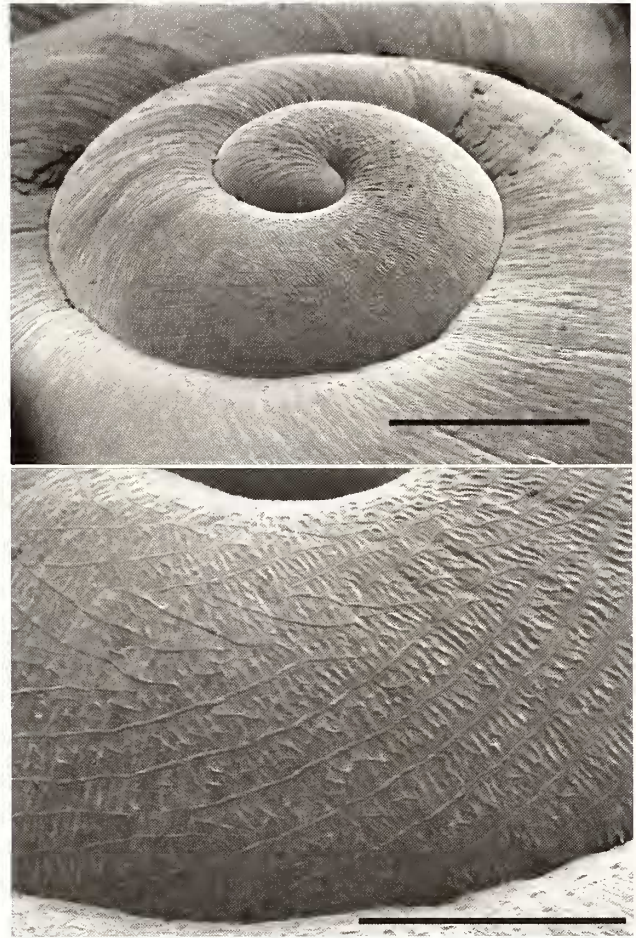


Figure 2. Scanning electron micrographs of the apical whorls of the shell of *Sonorella pedregosensis* Gilbertson and Radke, sp. nov., paratype. Oblique view and enlargement. LACM 3047. Scale bars = 1 mm (upper), 500 µm (lower).

Paratypes (Table 2, Fig. 5A): Paratypes similar to holotype; most specimens somewhat smaller overall. Seminal duct opening more visible (slit more opened) atop central protrusion on some stained paratypes compared to holotype. Largest paratype (no. 6) removed from snail with below average sized shell (Table 1, no. 10).

Type locality: Arizona, Cochise County, Pedregosa Mountains, Leslie Canyon National Wildlife Refuge (a unit of the San Bernardino National Wildlife Refuge Complex), 26 km N of Douglas, WNW facing talus slope, 31°35.526'N; 109°30.395'W. Elevation 1,421 m.

Leslie Canyon NWR was established to protect wetland habitat for federally listed endangered fishes. It is located at an interface between the Pedregosa and Swisshelm Mountains, characterized by both rhyolite and limestone formations. Live specimens of *Sonorella pedregosensis* and/or shells

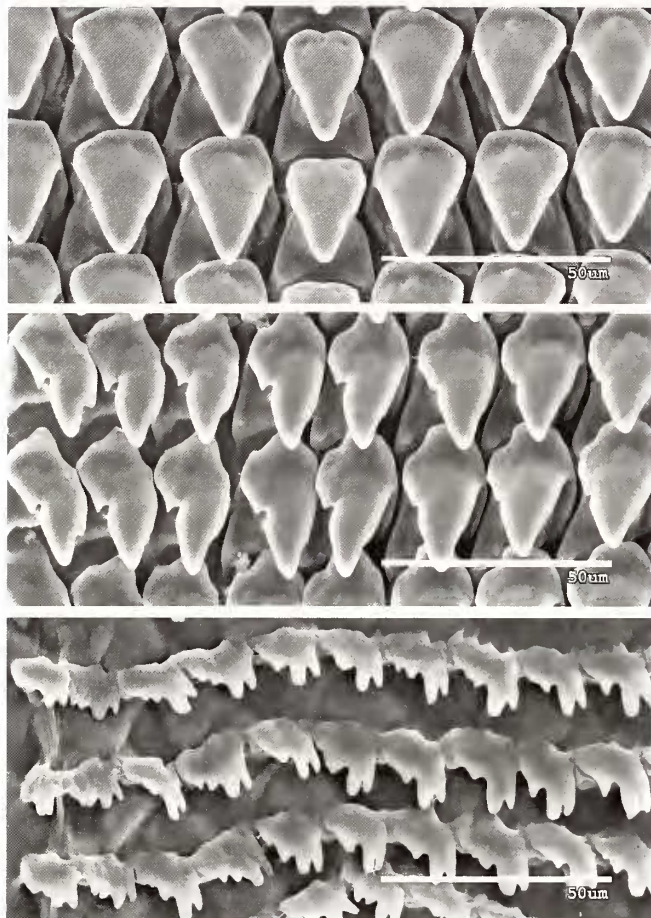


Figure 3. Scanning electron micrographs of radulae of *Sonorella pedregosensis* Gilbertson and Radke, sp. nov., paratypes. Upper image, central tooth and adjacent lateral teeth; middle image, transitional lateral-marginal teeth, numbers 11-18 (right to left); lower image, outer marginal teeth, numbers 32-41 (right to left). Scale bars = 50 µm.

have been found among rhyolite talus at several locations on the refuge. The area is characterized by Chihuahuan Desert scrub bisected by riparian woodland. Dominant vegetation at the collection site is composed of *Fraxinus velutina*, *Juglans major*, *Rhus microphylla*, *Sporobolus airoides* var. *Wrightii*, *Celtis reticulata*, *Acacia constricta*, and *Agave palmieri*. Average annual precipitation at Leslie Canyon is about 276 mm with rainfall occurring primarily during summer monsoonal thunderstorms (measured on-site by refuge staff using an "All Weather Gauge"). Temperature extremes for the area range from -10°C to 42°C (National Climate Data Center, Douglas FAA Airport location, station number 022664). Collecting is prohibited in the Leslie Canyon NWR without a Special Use Permit.

Disposition of types: Holotype (shell and slide of re-

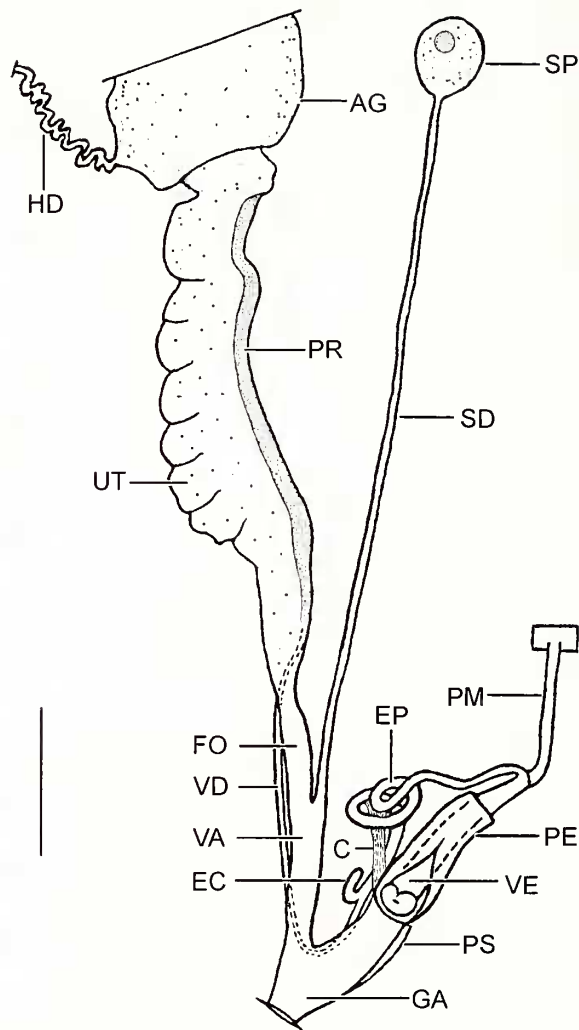


Figure 4. Drawing of the slide-mounted reproductive system of *Sonorella pedregosensis* Gilbertson and Radke, sp. nov., holotype (LACM 3046). Penis partially opened to expose verge. Abbreviations: AG, albumen gland; C, connective tissue; EC, epiphallic cecum; EP, epiphallus; FO, free oviduct; GA, genital atrium; HD, hermaphroditic duct; PE, penis; PM, penial retractor muscle; PR, prostate gland; PS, penial sheath; SD, spermathecal duct; SP, spermatheca; UT, uterus; VA, vagina; VD, vas deferens; VE, verge. Scale bar = 5 mm.

productive anatomy): LACM 3046. Paratypes: ANSP 412176 (2 shells); CNMO 1440 (2 shells); LACM 3047 (2 shells, 3 slides of reproductive anatomies), 3048 (6 shells); SBMNH 354176 (2 shells), 354183 (3 slides of reproductive anatomies); USNM 1073075 (2 shells).

Etymology: This species is named for the Pedregosa Mountains where it lives. For purposes where a common name is useful, the "Leslie Canyon talussnail" is proposed.

Discussion: *Sonorella pedregosensis* resembles *Sonorella*

Table 2. Lengths (mm) of selected reproductive organs of *Sonorella pedregosensis* Gilbertson and Radke, sp. nov., (LACM 3046,3047 [holotype, paratypes 1-3], SBMNH 354183 [paratypes 4-6]), and topotypes of *Sonorella binneyi*. Mean values for *S. pedregosensis* are for paratypes only. Abbreviation: sp./duct, spermatheca and spermathecal duct.

<i>S. pedregosensis</i>	Penis	Verge	Sheath	Vagina	Sp./duct
Holotype	8.3	4.6	4.0	4.8	29.0
Paratypes	7.0	4.3	3.5	5.4	—
	7.0	4.1	2.8	5.1	29.0
	7.5	4.2	2.9	5.8	21.8
	6.9	4.0	2.7	5.1	28.0
	7.2	4.4	2.7	5.6	31.1
	8.8	5.0	4.1	5.5	26.2
\bar{x}	7.4	4.3	3.1	5.4	27.2
<i>S. binneyi</i>					
LACM 153522	12.5	6.7	6.6	10.0	24.6
4802-A*	16.0	7.5	—	12.0	—
4910-A*	15.0	7.5	—	12.0	—
\bar{x}	14.5	7.2	6.6	11.3	24.6

* Miller 1967a,b (b, verge only)

binneyi Pilsbry and Ferriss, 1910 from Horseshoe Canyon, located on the eastern side of the Chiricahua Mountains. Like *S. binneyi*, the new species exhibits the hallmark characters of the “*S. binneyi* Complex Miller, 1967” of *Sonorella* species which include: (1) a relatively small, (comparatively) globose shell with a smooth, silky-lustrous periostracum and apical, spirally descending threads, and (2) a usually short, moderately thick, bluntly-rounded verge in the penis (see Pilsbry 1939, Miller 1967a, Bequaert and Miller 1973). Members of these two species also exhibit an unusually long, often coiled epiphallus, a long epiphallic cecum, and an initial insertion of the penial retractor muscle on the epiphallus noticeably above the apex of the penis. However, the shell of *S. pedregosensis* is somewhat smaller and darker and its shoulder band is darker and wider than that of *S. binneyi*. The apical whorls of *S. binneyi* exhibit spiral threads that are descending only. More significantly, the genitalia of *S. binneyi* are about twice as large as those of the new species (Table 2) and the glandiform apex of its verge includes the presence of a unique, lateral, subterminal, protrusible papilla with a terminal opening of the seminal duct (Miller 1967a,b, Fairbanks and Reeder 1980, Fig. 5B). (Pilsbry’s [1939] original description of the verge was erroneous, apparently based on an immature specimen). Populations of these two species are separated by about 32 km of varied terrain.

The only other presently described Chiricahuan member of the “*Sonorella binneyi* Complex” is *Sonorella neglecta* Gregg, 1951. Its shell and genitalia are significantly smaller than those of the new species and they differ in other respects.

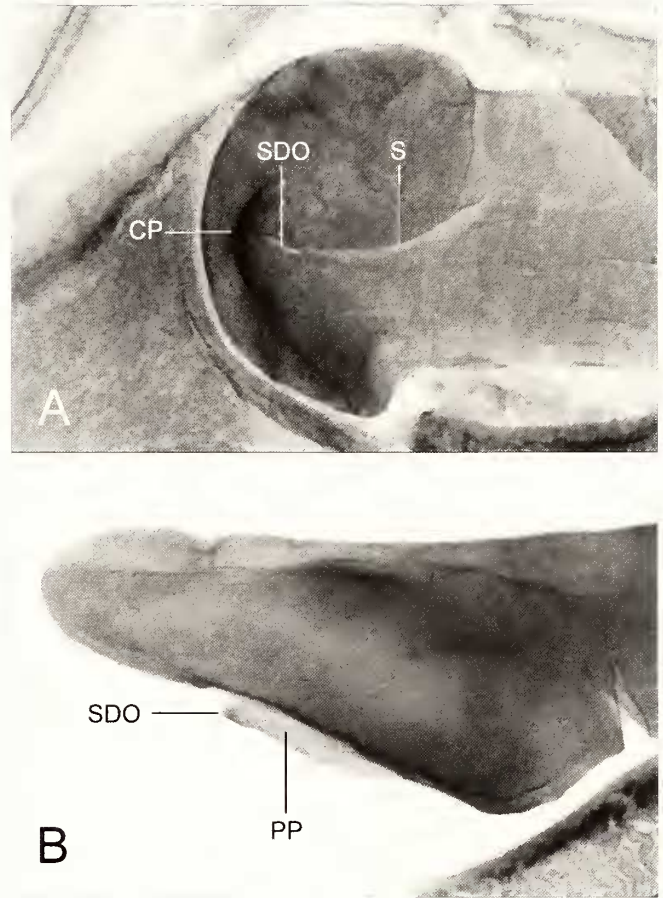


Figure 5. A, Photograph of the apical, glandiform structure of the verge of *Sonorella pedregosensis* Gilbertson and Radke sp. nov., paratype (Table 2, no. 6; SBMNH 354183) (Slit atypically along right edge of cleavage.) B, Photograph of the apical glandiform structure of the verge of *Sonorella binneyi* Pilsbry and Ferriss, 1910, topotype (LACM 153522). Both photographs are dorsal views with horizontal field widths of 2.7 mm. Abbreviations: CP, central protusion; PP, protrusible papilla; S, slit; SDO, seminal duct opening.

Individuals of *Sonorella bowiensis* Pilsbry, 1905 from the northern end of the Chiricahua Mountains have shell features similar to those of *Sonorella pedregosensis*. However, the verge of this species lacks an apical, glandiform structure. It does have a subterminal seminal duct orifice (Miller 1967a). This species was placed by Pilsbry (1939) in his “*Sonorella binneyi* Group” and was subsequently transferred by Miller (1967a) to his reconfigured “*Sonorella granulatisima* Pilsbry, 1902 Complex.”

The shell of *Sonorella pedregosensis* is rather similar to the shells of some other members of the “*Sonorella binneyi* Complex” inhabiting other mountain ranges to the west. These include *Sonorella tryoniana* Pilsbry and Ferriss, 1923 from the Patagonia Mountains, *Sonorella imperialis* Pilsbry

and Ferriss, 1923 from the Empire Mountains, and *Sonorella sitiens sitiens* Pilsbry and Ferriss, 1915 from the Las Guigas (and nearby) Mountains. However, the genitalia, especially the size and shape of the verge and the length of the epiphallus and epiphallic cecum, clearly identify the new species. Nominate *Sonorella baboquivariensis* Pilsbry and Ferriss, 1915 exhibits a glandiform structure at the tip of its verge but, because of its conic shape, it is easily separable from that of *S. pedregosensis*. In addition, its shell is more globose, more narrowly umbilicate, and the Baboquivari Mountains, where it lives, are located hundreds of kilometers to the west.

The validity of the informal *Sonorella* "species-groups" (or "complexes"), including the "*S. binneyi* Complex," has been brought into question by Naranjo-García (1988) and Roth (1996). Further research, including the use of molecular techniques, is needed to help clarify the relationships of these informal taxa.

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